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The occupational role of women in military service: Validation of occupation and prevalence of exposures in the Millennium Cohort Study

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Abstract
To better understand the US military's global peacekeeping and combat operations, which may expose a growing population of American servicewomen to challenging occupations and environments. Concordance between self-reported and electronic occupation codes for female participants in the Millennium Cohort was measured using kappa statistics. Multivariable logistic regression modeling was used to assess the odds of five self-reported potentially toxic environmental exposures or disturbing experiences among different occupational categories, while adjusting for demographic and military characteristics, including deployment. Self-reported occupations were moderately to highly reliable when compared with electronic occupation data. Active-duty and Reserve/Guard females differentially reported witnessing death or trauma and exposure to chemical or biological warfare, depleted uranium, or pesticides. Findings suggest that self-reported occupation can be used with a high degree of confidence. Occupational groups with higher odds of reporting military exposures of concern will be followed longitudinally through 2022 and prospectively compared using baseline and follow-up evaluations.

Keywords: *Occupational exposures, depleted uranium, military medicine, military personnel, veterans*

Introduction

Occupational exposures among servicewomen in the United States military have been of growing concern after policy changes in the early 1990s made it possible for women to fill combat-related roles (Center for Military Readiness Policy Analysis 2003, 2005; Harrell,

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Beckett et al. 2005). This policy shift toward expanded roles for women in the US military was given significant attention in 2002 after three enlisted women serving in combat support roles in Iraq were captured, and one was later found dead (Center for Reclaiming America 1997). This tragic incident came as a shock to many Americans, previously unaware that women were serving in occupations that posed war-related risks similar to those historically faced only by men.

Studies from the Vietnam War and the 1991 Gulf War have documented specific exposures of concern among deployed military women, including witnessing of death and morbidity due to war, disaster, or tragic event (Hobfoll et al. 1991; Orsillo et al. 1998; Carson et al. 2000; Carney et al. 2003); exposure to prisoners of war (Benotsch et al. 2000; Carney et al. 2003); chemical or biological warfare or countermeasures for these agents (Gray et al. 1999; Smith et al. 2002; Boyd et al. 2003; Carney et al. 2003; Smith et al. 2003, 2004a,b); depleted uranium (Carney et al. 2003; Macfarlane et al. 2005); and pesticides (Gambel et al. 1998; Carney et al. 2003; Macfarlane et al. 2005). These and other studies investigating exposures associated with morbidity and reproductive health outcomes (Hourani & Hilton 2000; Kang et al. 2000, 2001; Reutman et al. 2002; Araneta et al. 2003) highlight the growing occupational challenges faced by increasing numbers of women as they serve in an evolving military work force.

Understanding occupational risk factors among women has become increasingly critical in light of current military deployments around the world. Acquiring precise and reliable exposure information at the individual level is one of the most challenging aspects of epidemiologic studies. Objectively ascertained exposure data are often not available. Consequently, researchers must rely on self-reported data to assess associations between exposures and adverse health outcomes. Both assessment methods are limited in scope and inferential capabilities and may lead to disputes over scientific interpretation (Kuller 1995; Zavestoski et al. 2002). The Millennium Cohort Study intentionally oversampled female service members, accounting for 25% of the Cohort, in order to allow robust investigations by gender and to yield information on potential risk factors for long-term health outcomes by its longitudinal design. Identifying occupation and self-reported exposures within the Cohort is critical to address exposures that are of specific military concern. The purpose of this analysis is to investigate concordance between self-reported and electronically maintained occupation codes and to document baseline self-reported environmental exposures and disturbing evocative experiences, including witnessing death, witnessing trauma, chemical or biological warfare, depleted uranium, and pesticides that may be associated with occupational categories among US military women.

Materials and methods

Population and data sources

The invited Millennium Cohort Study participants were randomly selected from all US military personnel serving in October 2000, oversampling those who had been previously deployed, Reserve and National Guard members, and women, to ensure sufficient power to detect differences in smaller subgroups of the population. The probability-based sample, representing approximately 11.3% of the 2.2 million men and women in service as of 1 October, 2000, was provided by the Defense Manpower Data Center in California. Using a modified Dillman approach, Web and postal-based enrollment began in July 2001. Enrollment ended on 30 June 2003 with 77 047 consenting participants, or 35.9% of the invited, eligible, and contacted target population. The methodology of the Millennium Cohort Study has been described elsewhere in detail (Ryan et al. 2007).

Electronic personnel data included a personal identifier, gender, birth date, highest education level, marital status, race/ethnicity, past deployment to southwest Asia, Bosnia, or Kosovo between 1 January, 1998 and 1 October, 2000, pay grade, deployment to the 1991 Gulf War, service component (active duty and Reserve/Guard), service branch (Army, Navy, Coast Guard, Air Force, and Marines), and primary and secondary military occupations. Data at time of survey submission, or in close temporal proximity to submission, were used for occupation, service branch, pay grade, and marital status. Additionally, for this analysis, missing electronic personnel data on marital status and education were supplemented with available self-reported data from the survey. This reduced the number of individuals missing data for at least one important demographic characteristic from 1.5 – 0.4% of the Cohort.

Exposures and occupations

The Millennium Cohort questionnaire consisted of 67 items, including questions regarding demographics, exposures, and occupation. Of the 77 047 Millennium Cohort Study participants, 85.7% ($n = 66{,}035$) self-selected an occupation code. These codes were compared with occupation codes in electronically maintained Department of Defense personnel files to determine the level of concordance. Both electronically maintained and self-reported occupational codes were ascertained at the time of enrollment and standardized into 10 categories using the Department of Defense Occupational Conversion Index (Office of the Under Secretary of Defense Personnel and Readiness 2001) (combat specialists, electronics repair, communications and intelligence, healthcare specialists, other technical specialists, functional support specialists, electrical and mechanical repair, craft workers, service and supply, and trainees and other).

Much of the research following the 1991 Gulf War focused on retrospective self-reporting of these metrics. To reduce the potential for recall bias after the presentation of disease, the Millennium Cohort questionnaire includes a list of exposures to establish a baseline exposure history. Questions regarding unique occupational exposures were derived from the National Health Survey of Persian Gulf War Era Veterans (Kang et al. 2000; Gray et al. 2002). For the purposes of this investigation, nine self-reported occupational exposures of interest were grouped into five categories (Table I). These constructs included witnessing death, witnessing trauma, chemical or biological warfare, depleted uranium, and pesticides.

Table I. Millennium Cohort exposure question constructs.

Exposure grouping	Question
	Have you ever been exposed to any of the following?
Witnessing death	Witnessing death due to war, disaster or tragic event
Witnessing trauma	Maimed soldiers/civilians Prisoners of war/refugees
Chem/Bio warfare	Chemical or biological warfare agents Other medical countermeasures for chemical or biological warfare agent exposure Alarms necessitating wearing of chemical/biological warfare protective gear
	During the past 3 years, were you exposed to any of the following?
Depleted uranium	Depleted uranium
Pesticides	Pesticides, including creams, sprays, or uniform treatments Pesticides applied in the environment or around living facilities

Statistical analysis

Descriptive analyses of the Cohort by occupational category and the five exposure groups were completed. Concordance between self-reported occupation codes and electronically maintained occupation codes was measured for women and for the Cohort overall, using kappa statistics (Cohen 1960). Participants' self-reported occupation was compared with the electronic code at the time they submitted their questionnaire. If no electronic code was on file for the same month as the questionnaire submission, then the code on file closest to the month of submission was used. For these analyses, the level of agreement was measured as follows: kappa = 0.8 – 1.0 denoting almost perfect agreement, 0.6 – 0.8 substantial agreement, 0.4 – 0.6 moderate agreement, 0.2 – 0.4 fair agreement, and 0.0 – 0.2 slight or poor agreement (Landis & Koch 1977).

Descriptive analyses of women in the Cohort stratified by active-duty and Reserve/Guard status were completed. Univariate analyses, including Chi-square tests, were employed to assess the significance of unadjusted associations between self-reported exposures and occupation. An exploratory analysis was conducted to examine regression diagnostics, significant associations, and possible confounding, while simultaneously adjusting for other variables in the model. Multivariable logistic regression was used to compare the adjusted odds of the exposures of interest among broad occupation categories, while controlling for other possible confounders (Hosmer & Lemeshow 2000). All analyses were completed using SAS software (version 9.1, SAS Institute, Inc., Cary, North Carolina), and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for personnel with complete covariate data (SAS Institute Inc. 2004).

Results

The first enrollment panel for the Millennium Cohort Study resulted in 77 047 consenting participants. Of those, 85.7% ($n = 66{,}028$) had complete self-report and electronic occupation data. Investigation of concordance between electronic and self-reported data showed substantial agreement for the Cohort as a whole (kappa = 0.68, 95% CI = 0.67 – 0.68), as well as for women only (kappa = 0.65, 95% CI = 0.64 – 0.66) (Figure 1). Those who were electronically labeled as trainees or others were found to have poor agreement with their self-reported occupation (kappa = 0.12); however, healthcare specialists displayed almost perfect agreement (kappa = 0.84). Self-reported electronic and combat specialties had only fair concordance, and all other occupational categories had either moderate or substantial agreement. Women who were active duty personnel had notably higher concordance (kappa = 0.69, 95% CI = 0.68 – 0.71) than Reserve/Guard personal (kappa = 0.59, 95% CI = 0.58 – 0.60) (data not shown).

There were 20 632 Millennium Cohort women of whom 97.6% ($n = 20\ 139$) had complete demographic and self-reported exposure data. Regression diagnostics for investigating pairwise correlations and the variance inflation factor of occupation and the demographic variables suggested that collinearity among these variables was not present. Exploratory model analyses found that the effect of occupation on reporting of exposures was modified by whether the individual was active-duty or Reserve/Guard status. Therefore, stratified analyses are presented.

The most common occupations among the 10 539 active-duty women included specialists in functional support (32.2%), healthcare (21.7%), and communications and intelligence (9.6%) (Table II). Active-duty women had a mean age of 29.7 years and consisted of 45.8% high school educated, 51.9% married, 55.6% white, 76.7% enlisted, and 41.3% Army.

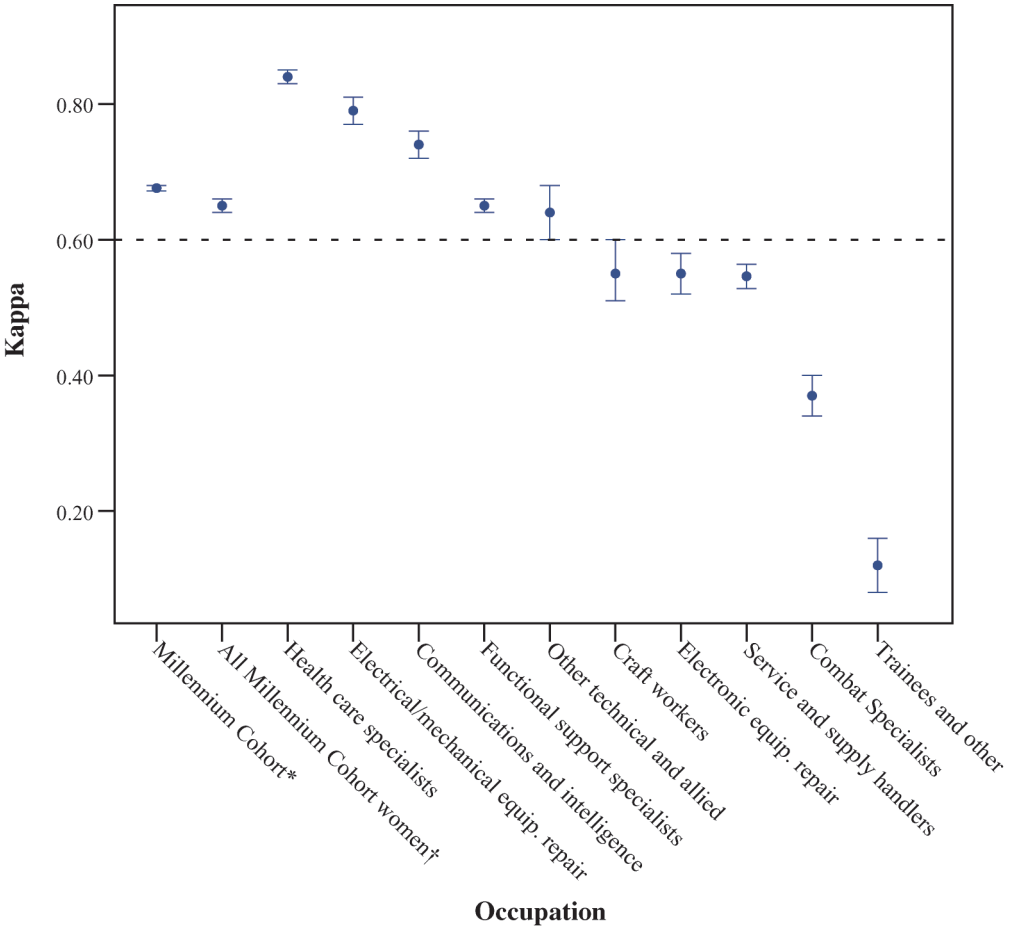

Figure 1. Kappa statistics and 95% CI for electronically maintained occupation codes versus self-reported occupation codes. *Millennium Cohort participants who self-reported their occupation, $n = 66{,}028$; †Millennium Cohort women who self-reported their occupation, $n = 17\ 189$. Kappa of 0.60 interpreted as substantial agreement from JR Landis and GG Koch. The measurement of observer agreement for categorical data (Landis & Koch 1977).

Additionally, 19.7% had deployment experience in Southwest Asia, Bosnia or Kosovo from 1998–2000 and 5.8% were deployed to the 1991 Gulf War (Table II). Univariate analyses revealed that occupation, age, education, pay grade, and service branch were significantly associated with reporting witnessing death, witnessing trauma, exposure to chemical or biological warfare, exposure to depleted uranium, and exposure to pesticides ($p < 0.05$) (Table II).

Multivariable logistic regression revealed that, after adjustment for age, education, marital status, race/ethnicity, pay grade, branch of service, deployment experience in Southwest Asia, Bosnia or Kosovo from 1998–2000, and deployment to the 1991 Gulf War, active-duty women health care specialists were significantly more likely to report witnessing death (OR = 2.50, 95% CI = 1.93–3.25) or trauma (OR = 2.51, 95% CI = 1.88–3.36) when compared with combat specialists (Table III). Active-duty women specialists in the field of electrical/mechanical equipment repair were significantly more likely to report witnessing

Table II. Occupational specialty and demographic characteristics of active-duty Millennium Cohort females by self-reported exposure*.

Characteristic	Active-duty women $n = 10\,539$	Witnessing death $n = 1498$	Witnessing trauma $n = 1189$	Chem/Bio warfare $n = 1210$	Depleted uranium $n = 127$	Pesticides $n = 3106$
Occupational specialty (*n*, %)						
Combat specialists	714 (6.7)	79 (5.3)	64 (5.4)	85 (7.0)	13 (10.2)	225 (7.2)
Electronic repair	861 (8.2)	86 (5.7)	66 (5.5)	105 (8.7)	24 (18.9)	278 (9.0)
Communications/Intelligence	1009 (9.6)	129 (8.6)	109 (9.2)	102 (8.4)	4 (3.2)	281 (9.0)
Healthcare specialists	2283 (21.7)	543 (36.3)	472 (39.7)	279 (23.1)	13 (10.2)	772 (24.9)
Other technical specialists	301 (2.9)	30 (2.0)	26 (2.2)	49 (4.0)	9 (7.1)	87 (2.8)
Functional support specialists	3391 (32.2)	339 (22.6)	248 (20.8)	342 (28.3)	17 (13.4)	804 (25.9)
Electrical/mechanical	725 (6.9)	114 (7.6)	58 (4.9)	97 (8.0)	33 (26.0)	270 (8.7)
Craft workers	154 (1.4)	18 (1.2)	13 (1.1)	24 (2.0)	7 (5.5)	66 (2.1)
Service & supply	995 (9.4)	143 (9.6)	127 (10.7)	119 (9.8)	4 (3.2)	292 (9.4)
Trainees and other	106 (1.0)	17 (1.1)	6 (0.5)	8 (0.7)	3 (2.3)	31 (1.0)
Age, years (mean, SD†)	29.7 (7.9)	31.4 (8.6)	33.0 (8.3)	32.4 (8.1)	27.9 (7.0)	30.7 (8.1)
Education (*n*, %)						
No high school diploma	148 (1.4)	30 (2.0)	18 (1.5)	23 (1.9)	5 (4.0)	52 (1.7)
High school diploma	4829 (45.8)	674 (45.0)	477 (40.1)	502 (41.5)	69 (54.3)	1392 (44.8)
Some college	2791 (26.5)	336 (22.4)	229 (19.3)	358 (29.6)	25 (19.7)	759 (24.4)
Bachelor's degree	1663 (15.8)	247 (16.5)	236 (19.8)	184 (15.2)	22 (17.3)	524 (16.9)
Master's/PhD	1108 (10.5)	211 (14.1)	229 (19.3)	143 (11.8)	6 (4.7)	379 (12.2)
Marital status (*n*, %)						
Single	3781 (35.9)	525 (35.0)	367 (30.9)	371 (30.7)	61 (48.0)	1005 (32.4)
Married	5474 (51.9)	786 (52.5)‡	656 (55.2)	631 (52.1)	59 (46.5)	1691 (54.4)
Divorced	1284 (12.2)	187 (12.5)	166 (13.9)	208 (17.2)	7 (5.5)	410 (13.2)
Race/ethnicity (*n*, %)						
White non-Hispanic	5857 (55.6)	865 (57.8)	682 (57.4)	702 (58.0)‡	85 (66.9)	1847 (59.5)
Black non-Hispanic	2482 (23.5)	276 (18.4)	189 (15.9)	265 (21.9)	11 (8.7)	598 (19.2)
Other	2200 (20.9)	357 (23.8)	318 (26.7)	243 (20.1)	31 (24.4)	661 (21.3)
Military pay grade (*n*, %)						
Enlisted	8090 (76.7)	1069 (71.4)	762 (64.1)	913 (75.5)	102 (80.3)	2295 (73.9)
Officer	2449 (23.3)	429 (28.6)	427 (35.9)	297 (24.5)	25 (19.7)	811 (26.1)
Branch of service (*n*, %)						
Army	4351 (41.3)	670 (44.7)	653 (54.9)	553 (45.7)	48 (37.8)	1335 (43.0)
Navy/Coast Guard	2366 (22.5)	369 (24.6)	211 (17.7)	218 (18.0)	51 (40.2)	694 (22.3)
Marines	383 (3.6)	49 (3.3)	21 (1.8)	34 (2.8)	0 (0.0)	134 (4.3)
Air Force	3439 (32.6)	410 (27.4)	304 (25.6)	405 (33.5)	28 (22.0)	943 (30.4)
Deployed from 1998–2001§ (*n*, %)						
Deployment experience	2072 (19.7)	330 (22.0)	317 (26.7)	296 (24.5)	49 (38.6)	633 (20.4)
No deployment experience	8467 (80.3)	1168 (78.0)	872 (73.3)	914 (75.5)	78 (61.4)	2473 (79.6)‡
Deployed to 1991 Gulf War¶ (*n*, %)						
Deployment experience	614 (5.8)	144 (9.6)	194 (16.3)	331 (27.4)	5 (3.9)	232 (7.5)
No deployment experience	9925 (94.2)	1354 (90.4)	995 (83.7)	879 (72.6)	122 (96.1)	2874 (92.5)

*Exposures include witnessing death due to war, disaster, or tragic event; maimed soldiers or prisoners of war/refugees; chemical or biological warfare agents or countermeasures for these agents; depleted uranium; and pesticides encountered in the environment or through personal use; †Standard deviation. ‡Association not significant based on Pearson Chi-square test of association at $\alpha = 0.05$ level; §Participant deployed to Southwest Asia, Bosnia, or Kosovo from 1998–2000; ¶Participant deployed to the 1991 Gulf War.

Table III. Adjusted odds of self-reporting exposures* among active-duty Millennium Cohort women by occupational specialty and deployment experience.

Characteristic	Witnessing death $n = 10\,539$ OR (CI)†	Witnessing trauma $n = 10\,539$ OR (CI)†	Chem/Bio warfare $n = 10\,539$ OR (CI)†	Depleted uranium $n = 9796$ OR (CI)†	Pesticides $n = 9788$ OR (CI)†
Occupational category					
Combat specialists‡	1.00 –	1.00 –	1.00 –	1.00 –	1.00 –
Electronic repair	0.85 (0.61, 1.18)	0.80 (0.55, 1.16)	0.90 (0.65, 1.25)	1.75 (0.86, 3.53)	1.00 (0.80, 1.25)
Communications/Intelligence	1.17 (0.86, 1.59)	1.22 (0.87, 1.75)	0.73 (0.52, 1.01)	0.25 (0.08, 0.79)	0.80 (0.64, 1.00)
Healthcare specialists	2.50 (1.93, 3.25)	2.51 (1.88, 3.36)	0.85 (0.64, 1.12)	0.44 (0.20, 0.98)	0.98 (0.81, 1.19)
Other technical & allied	0.92 (0.59, 1.47)	1.09 (0.66, 1.80)	1.42 (0.94, 2.15)	2.25 (0.89, 5.69)	0.85 (0.62, 1.15)
Functional support specialists	0.92 (0.70, 1.21)	0.86 (0.63, 1.17)	0.70 (0.53, 0.92)	0.40 (0.18, 0.88)	0.64 (0.52, 0.77)
Electrical/mechanical	1.42 (1.03, 1.96)	0.95 (0.64, 1.40)	1.08 (0.77, 1.52)	2.71 (1.32, 5.59)	1.29 (1.02, 1.63)
Craft workers	1.02 (0.59, 1.78)	1.10 (0.58, 2.09)	1.27 (0.76, 2.15)	2.89 (1.08, 7.78)	1.65 (1.13, 2.41)
Service & supply	1.28 (0.95, 1.73)	1.24 (0.89, 1.73)	0.72 (0.52, 1.00)	0.28 (0.09, 0.89)	0.83 (0.66, 1.03)
Trainees and other	1.70 (0.96, 3.03)	0.81 (0.33, 1.94)	0.72 (0.34, 1.57)	1.78 (0.49, 6.44)	0.98 (0.61, 1.55)
Past deployment status§					
No deployment experience‡	1.00 –	1.00 –	1.00 –	1.00 –	1.00 –
Deployment experience	1.35 (1.17, 1.55)	2.01 (1.72, 2.33)	1.37 (1.17, 1.60)	2.27 (1.55, 3.31)	1.09 (0.97, 1.21)

*Exposures include witnessing death due to war, disaster, or tragic event; maimed soldiers or prisoners of war/refugees; chemical or biological warfare agents or countermeasures for these agents; depleted uranium; pesticides encountered in the environment or through personal use. The number self-reporting exposure to depleted uranium and pesticides is based on those answering yes or no after removing those reporting not knowing of exposure; †Odds ratios (OR) and associated 95% confidence intervals (CI) from multiple logistic regression for those with complete demographic data are adjusted for age, education, marital status, race/ethnicity, pay grade, branch of service, and deployment to the 1991 Gulf War; ‡Reference category; §Participant deployed to Southwest Asia, Bosnia, or Kosovo from 1998–2000.

death (OR = 1.42, 95% CI = 1.03 – 1.96), exposure to depleted uranium (OR = 2.71, 95% CI = 1.32 – 5.59), and pesticides (OR = 1.29, 95% CI = 1.02 – 1.63), when compared with combat specialists. Craft workers also reported significantly more exposure to depleted uranium (OR = 2.89, 95% CI = 1.08 – 7.78) and pesticides (OR = 1.65, 95% CI = 1.13 – 2.41), when compared with combat specialists. Additionally, active-duty women deployed to Southwest Asia, Bosnia, or Kosovo between 1998 and 2000 were significantly more likely to report witnessing death (OR = 1.35, 95% CI = 1.17 – 1.55), witnessing trauma (OR = 2.01, 95% CI = 1.72 – 2.33), exposure to chemical or biological warfare (OR = 1.37, 95% CI = 1.17 – 1.60), and exposure to depleted uranium (OR = 2.27, 95% CI = 1.55 – 3.31) when compared with those not deployed to these contingency operations.

The most common occupations among the 9600 women in the Reserves or National Guard included specialists in functional support (40.1%), combat (14.8%), and healthcare (14.6%) (Table IV). Reserve/Guard women had a mean age of 34.6 years and consisted of 36.1% high school educated, 46.5% married, 68.5% white, 76.7% enlisted, 59.8% Army, 5.7% with deployment experience in Southwest Asia, Bosnia, or Kosovo from 1998 – 2000 and 6.8% with history of deployment to the 1991 Gulf War (Table IV). Univariate analyses revealed that occupation, age, education, and pay grade were significantly associated with reporting witnessing death, witnessing trauma, exposure to chemical or biological warfare, exposure to depleted uranium, and exposure to pesticides ($p < 0.05$) (Table IV).

Multivariable logistic regression revealed that, after adjustment for age, education, marital status, race/ethnicity, pay grade, branch of service, deployment experience in Southwest Asia, Bosnia, or Kosovo from 1998 – 2000, and deployment to the 1991 Gulf War, Reserve/Guard women who were in combat specialties were more likely to report witnessing death or trauma than nearly all of the other occupational categories (Table V). Reserve/Guard women in the field of electrical/mechanical equipment repair reported significantly more exposure to depleted uranium (OR = 4.50, 95% CI = 1.28 – 15.89) and pesticides (OR = 1.34, 95% CI = 1.04 – 1.74) when compared with combat specialists. Deployment experience was significantly associated with reporting exposure to chemical or biological warfare (OR = 1.65), depleted uranium (OR = 2.89), and pesticides (OR = 1.25).

Discussion

Policy shifts in the 1990s created many new opportunities for women to participate in expanded combat-related roles in the US military. Following the Vietnam War and institution of the All Volunteer Force in 1973, women recruited into military service increased steadily from 2% to approximately 9% by the time of the 1991 Gulf War. Currently women represent 15% of the US military (Center for Military Readiness Policy Analysis) and constitute a unique group based on their new occupational exposures, especially during deployment to combat areas such as Afghanistan and Iraq. Understanding the limitations and strengths of electronically maintained occupation data as well as self-reported occupational exposures are crucial to the interpretation of findings and conclusions based on these data.

The first objective of this study was to establish the degree of concordance between self-reported occupation and electronically maintained personnel occupation data. Overall, reliability was found to be substantial for the entire Cohort as well as for women specifically. However, there was some variability over the 10 occupation categories, with the lowest degree of reliability found among trainees and others. The poor measure of agreement between self-report and electronic data for this category might be expected with individuals who are in school or training if they have a belief of what their occupation is or will be. Only the category of healthcare specialists was found to have an almost perfect measure of agreement.

Table IV. Occupational specialty and demographic characteristics of Reserve/Guard Millennium Cohort females by self-reported exposure*.

Characteristic	Reserve/Guard women $n=9600$	Witnessing death $n=1460$	Witnessing trauma $n=1175$	Chem/Bio warfare $n=1135$	Depleted uranium $n=44$	Pesticides $n=2720$
Occupational category (*n*, %)						
Combat specialists	1419 (14.8)	352 (24.1)	324 (27.6)	220 (19.4)	6 (13.6)	474 (17.4)
Electronic repair	325 (3.4)	41 (2.8)	24 (2.1)	39 (3.4)	1 (2.3)	99 (3.7)
Communications/ Intelligence	413 (4.3)	60 (4.1)	50 (4.3)	39 (3.4)	2 (4.5)	115 (4.2)
Healthcare specialists	1400 (14.6)	292 (20.0)	241 (20.5)	180 (15.9)	5 (11.3)	401 (14.7)
Other technical specialists	238 (2.5)	23 (1.6)	20 (1.7)	41 (3.6)	1 (2.3)	65 (2.4)
Functional support specialists	3849 (40.1)	425 (29.1)	306 (26.0)	373 (32.9)	12 (27.3)	1001 (36.8)
Electrical/mechanical	467 (4.8)	66 (4.5)	45 (3.8)	53 (4.7)	12 (27.3)	147 (5.4)
Craft workers	189 (2.0)	20 (1.4)	18 (1.5)	26 (2.3)	1 (2.3)	51 (1.9)
Service & supply	944 (9.8)	126 (8.6)	115 (9.8)	133 (11.7)	3 (6.8)	274 (10.1)
Trainees and other	356 (3.7)	55 (3.8)	32 (2.7)	31 (2.7)	1 (2.3)	93 (3.4)
Age, years (mean, SD†)	34.6 (9.9)	36.7 (9.6)	38.7 (9.6)	37.2 (9.7)	36.5 (9.4)	36.3 (9.7)
Education (*n*, %)						
No high school diploma	1286 (13.4)	195 (16.4)	134 (11.4)	141 (12.4)	4 (9.1)	310 (11.4)
High school diploma	3468 (36.1)	491 (33.6)	362 (30.8)	367 (32.4)	17 (38.6)	919 (33.8)
Some college	2398 (25.0)	333 (2.8)	274 (23.3)	275 (24.2)	15 (34.1)	688 (25.3)
Bachelor's degree	1716 (17.9)	294 (20.1)	265 (22.6)	234 (20.6)	6 (13.6)	560 (20.6)
Master's/PhD	732 (7.6)	147 (10.1)	140 (11.9)	118 (10.4)	2 (4.6)	243 (8.9)
Marital status (*n*, %)						
Single	3614 (37.6)	453 (31.0)	347 (29.5)	394 (34.7)	12 (27.3)	881 (32.4)
Married	4462 (46.5)	714 (48.9)	588 (50.1)	535 (47.1)	22 (50.0)‡	1356 (49.8)
Divorced	1524 (15.9)	293 (20.1)	240 (20.4)	206 (18.2)	10 (22.7)	483 (17.8)
Race/ethnicity (*n*, %)						
White non-Hispanic	6578 (68.5)	1080 (74.0)	906 (77.1)	788 (69.4)‡	35 (79.6)‡	2027 (74.5)
Black non-Hispanic	1963 (20.5)	244 (16.7)	167 (14.2)	230 (20.3)	6 (13.6)	464 (17.1)
Other	1059 (11.0)	136 (9.3)	102 (8.7)	117 (10.3)	3 (6.8)	229 (8.4)
Military pay grade (*n*, %)						
Enlisted	7365 (76.7)	980 (67.1)	735 (62.6)	801 (70.6)	38 (86.4)	1972 (72.5)
Officer	2235 (23.3)	480 (32.9)	440 (37.4)	334 (29.4)	6 (13.6)	748 (27.5)
Branch of service (*n*, %)						
Army	5742 (59.8)	932 (63.8)	720 (61.3)	706 (62.2)	21 (47.7)	1578 (58.0)
Navy/Coast Guard	1204 (12.5)	172 (11.8)	145 (12.3)	100 (8.8)	5 (11.4)	361 (13.3)
Marines	104 (1.1)	11 (0.8)	9 (0.8)	9 (0.8)	0 (0.0)	34 (1.2)
Air Force	2550 (26.6)	345 (23.6)	301 (25.6)‡	320 (28.2)	18 (40.9)‡	747 (27.5)‡
Past deployment status§ (*n*, %)						
Deployment experience	550 (5.7)	76 (5.2)	73 (6.2)	89 (7.8)	9 (20.5)	182 (6.7)
No deployment experience	9050 (94.3)	1384 (94.8)‡	1102 (93.8)‡	1046 (92.2)	35 (79.5)	2538 (93.3)
Deployed to 1991 Gulf War¶ (*n*, %)						
Deployment experience	656 (6.8)	170 (11.6)	263 (22.4)	430 (37.9)	10 (22.7)	213 (7.8)
No deployment experience	8944 (93.2)	1290 (88.4)	912 (77.6)	705 (62.1)	34 (77.3)	2507 (92.2)

*Exposures include witnessing death due to war, disaster, or tragic event; maimed soldiers or prisoners of war/ refugees; chemical or biological warfare agents or countermeasures for these agents; depleted uranium; and pesticides encountered in the environment or through personal use; †Standard deviation; ‡Association not significant based on Pearson Chi-square test of association at $\alpha=0.05$ level; §Participant deployed to Southwest Asia, Bosnia, or Kosovo from 1998–2000; ¶Participant deployed to the 1991 Gulf War.

Table V. Adjusted odds of self-reporting exposures* among Reserve/Guard Millennium Cohort women by occupational specialty and deployment experience.

Characteristic	Witnessing death $n=9600$ OR (CI)†	Witnessing trauma $n=9600$ OR (CI)†	Chem/Bio warfare $n=9600$ OR (CI)†	Depleted uranium $n=9119$ OR (CI)†	Pesticides $n=9032$ OR (CI)†
Occupational category					
Combat specialists‡	1.00 –	1.00 –	1.00 –	1.00 –	1.00 –
Electronic repair	0.55 (0.39, 0.79)	0.40 (0.25, 0.62)	1.06 (0.70, 1.61)	0.61 (0.07, 5.50)	1.10 (0.84, 1.45)
Communications/Intelligence	0.66 (0.48, 0.91)	0.69 (0.49, 0.98)	0.70 (0.46, 1.07)	0.78 (0.14, 4.38)	0.94 (0.73, 1.22)
Healthcare specialists	1.02 (0.83, 1.26)	1.08 (0.86, 1.36)	1.02 (0.77, 1.35)	0.61 (0.15, 2.39)	1.05 (0.87, 1.27)
Other technical & allied	0.44 (0.27, 0.70)	0.54 (0.32, 0.90)	1.92 (1.24, 2.97)	0.77 (0.08, 7.42)	1.04 (0.75, 1.45)
Functional support specialists	0.47 (0.39, 0.58)	0.44 (0.35, 0.55)	0.81 (0.63, 1.04)	0.49 (0.15, 1.66)	0.89 (0.75, 1.05)
Electrical/mechanical	0.67 (0.49, 0.93)	0.63 (0.43, 0.92)	1.15 (0.78, 1.71)	4.50 (1.28, 15.89)	1.34 (1.04, 1.74)
Craft workers	0.47 (0.28, 0.77)	0.59 (0.34, 1.01)	1.24 (0.74, 2.10)	1.02 (0.11, 9.83)	1.10 (0.76, 1.58)
Service & supply	0.58 (0.45, 0.74)	0.70 (0.54, 0.92)	1.07 (0.79, 1.44)	0.63 (0.14, 2.95)	1.13 (0.92, 1.38)
Trainees and other	0.68 (0.49, 0.94)	0.52 (0.35, 0.78)	0.76 (0.48, 1.19)	0.90 (0.10, 8.04)	0.99 (0.75, 1.30)
Past deployment status§					
No deployment experience‡	1.00 –	1.00 –	1.00 –	1.00 –	1.00 –
Deployment experience	1.04 (0.80, 1.35)	1.27 (0.97, 1.68)	1.65 (1.24, 2.18)	2.89 (1.22, 6.87)	1.25 (1.03, 1.53)

*Exposures include witnessing death due to war, disaster, or tragic event; maimed soldiers or prisoners of war/refugees; chemical or biological warfare agents or countermeasures for these agents; depleted uranium; pesticides encountered in the environment or through personal use. The number self-reporting exposure to depleted uranium and pesticides is based on those answering yes or no after removing those reporting not knowing of exposure; †Odds ratios (OR) and associated 95% confidence intervals (CI) from multiple logistic regression for those with complete demographic data are adjusted for age, education, marital status, race/ethnicity, pay grade, branch of service, and deployment to the 1991 Gulf War; ‡Reference category; §Participant deployed to Southwest Asia, Bosnia, or Kosovo from 1998–2000.

Although near-perfect agreement might be expected for a characteristic such as one's occupation, changes in military occupation occur with some regularity and might not be reflected completely in electronic data. The finding of lower concordance of self-report and electronic occupation among Reserve/Guard women is reflective of a force called upon during a high tempo period to do various jobs that may not be in the specific job description of the occupation specialty listed.

The second objective was to describe occupational exposures among a current cohort of US military women. The differences in occupational groups and associated exposures among active-duty and Reserve/Guard women became evident after interactions were investigated. These differences in exposures might be expected between two distinct groups of professional military and 'citizen soldiers' who may receive different training and may take on different roles during deployment operations. Active-duty women were, on average, five years younger, more educated, and more likely to be married than their Reserve/Guard counterparts. It was interesting that Reserve/Guard women made up proportionally more of the combat specialists group than active-duty women, who made up a larger proportion of the healthcare and communications/intelligence occupations. In light of the many differences found between active-duty and Reserve/Guard military women, it is noteworthy that electrical and mechanical repair specialists from both groups reported significantly more exposure to depleted uranium and pesticides when compared with combat specialists, and this finding should be considered for more focused investigation.

The 1991 Gulf War and its aftermath of increased symptom reporting and multi-symptom illnesses among some veterans focused a great deal of attention on environmental and combat-related exposures, but studies among female veterans have been limited. In a population-based survey of women and men five years after the 1991 Gulf War, deployed women reported similar theater military experiences overall, but reported greater use of healthcare services following deployment (Carney et al. 2003). The results of another survey limited to Air Force women indicated that six years following Gulf War deployment, these women continued to self-report more overall health problems than women deployed to other locations (Pierce 2005). Because deployment, combat stresses, and occupational exposures may affect women in different ways compared with men (Norwood et al. 1997; Lindstrom et al. 2006), there is a need for more reliable data on the risks associated with various military occupations, deployment to specific locations, and stressful deployment experiences.

It should be noted that the exposures reported in baseline Millennium Cohort data precede the current deployment to Iraq and/or Afghanistan. US military women supporting the current war face numerous combat and deployment-related exposures that may not have been present in past conflicts. Sparse research has been done investigating occupational exposures among this unique population of deploying women, some of whom are newly integrated into combat-related roles. Recent studies show that the traditional wartime stressors, such as exposure to chemical or biological warfare agents and dealing with death and prisoners of war, are being complicated by new stressors unique to the current conflict, such as suicide bombings, improvised explosive devices, and threats of violent abuse if captured (Hoge et al. 2004; Reeves et al. 2005). These complex threats may take an even greater toll on women as they struggle between their military duty and their role as family nurturers (McNulty 2005). Even occupations such as healthcare specialists may expose women to the same serious risks as front-line fighters (Reeves et al. 2005). As the possibility advances of women being even further integrated into combat operations, including the perils of ground combat (Center for Military Readiness Policy Analysis 2005), the current population of military servicewomen should be followed closely for potential short- and long-term adverse health outcomes related to occupational and environmental exposures.

Some limitations to these analyses should be noted. The study population consisted of a subset of female responders to the Millennium Cohort questionnaire and might not be representative of all women in the military. In addition, the kappa statistic is dependent on the true prevalence of the variable being examined and may lack portability to other populations (Thompson & Walter 1988). Also, it was not possible to discern those exposures that are truly unique to military service from those that might also be encountered through other occupational or non-occupational activities. Thus, caution must be exercised when interpreting the associations found between occupations and exposures thought to be more prevalent among military workers. Further, after conducting stratified analyses for active-duty and Reserve/Guard personnel, the many statistically significant associations found between occupational categories and exposure components may have been due to chance alone because of the many comparisons made in these analyses. Lastly, although the reliability of self-reported occupations was investigated in this report, self-reported occupational exposure data could not be evaluated against objective exposure metrics.

Despite these limitations, the accuracy of the kappa estimates were maximized because of the capability of the self-reported occupation codes to be matched with electronic codes in the same month that the survey was submitted. Additionally, self-reported data are invaluable for the information they provide that is not available elsewhere. Finally, the large sample size of women for this study allowed for robust estimation of associations between occupation and exposures even after stratification.

In summary, the expanded role of women in combat-related occupations in the US military is an important consideration for occupational health studies such as the Millennium Cohort Study. This report documents the substantial reliability of self-reported occupation when compared with electronically maintained data. Further, women in certain occupations were at increased odds of reporting particular exposures of concern and they constitute subgroups that should be followed for health outcomes. These baseline exposure data are an important step to investigating exposure to disease pathways. In the future, the Millennium Cohort Study (Ryan et al. 2007) will longitudinally follow both military-specific as well as civilian occupational exposures and link these baseline and follow-up exposure data to important health outcomes to better address the impact of military service on long-term health.

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14. ABSTRACT (maximum 200 words)

Objectives: The US military's global peacekeeping and combat operations expose a growing population of American servicewomen to challenging occupations and environments.
Methods: Concordance between self-reported and electronic occupation codes for female participants in the Millennium Cohort was measured using kappa statistics. Multivariable logistic regression modeling was used to assess the odds of five self-reported exposures among different occupational categories, while adjusting for demographic and military characteristics, including deployment.
Results: Self-reported occupations were moderately to highly reliable when compared with electronic occupation data. Active-duty and Reserve/Guard females differentially reported witnessing death or trauma and exposure to chemical or biological warfare, depleted uranium, or pesticides.
Conclusions: Findings suggest that self-reported occupation can be used with a high degree of confidence. Occupational groups with higher odds of reporting military exposures of concern should be followed longitudinally from this baseline evaluation.

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occupational exposures, depleted uranium, military medicine, military personnel, veterans, combat disorders

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